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Biodiversity and incidence of defoliating caterpillars with reference to *Spodoptera frugiperda* (Lepidoptera: Noctuidae, J.E. Smith) in rainfed sorghum (*Sorghum bicolor* L.) fields in the Far North of Cameroon

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Abstract

Sorghum is produced in arid regions of Africa for human consumption. But its availability is compromised by several factors, among which phytophagous insects are the most devastating. After the invasion of Africa by the armyworm, *Spodoptera frigiperda* (Lepidoptera: Noctuidae, J.E. Smith), the damages are more serious in the fields. Defoliating caterpillars are then a major constraint. This work was set up to evaluate its populations alongside native defoliating species of rainfed sorghum plants in the field and to determine their incidence in the Far North Region of Cameroon. Through a sampling of 120 fields from 30 localities of Diamare Division, 9 species of caterpillars belonging to 6 genera and 6 families were identified. The species *Spodoptera frugiperda* J.E. Smith, which had represented more than 70% of the caterpillars collected, was still the most abundant in all fields and in all localities. The estimated Incidences ranged from 12.74% of plants attacked to 24.19%. Cultivation practices, the varieties of rainfed sorghum produced and the cultural landscape of the sampled localities had been identified as factors having induced varied average incidences and a statistically significant difference observed between certain localities.

Keywords : defoliating caterpillars, *Spodoptera frugiperda*, rainfed sorghum, *Sorghum bicolor*

Introduction

Sorghum (*Sorghum bicolor* L.) is the most consumed cereal in tropical regions with a rainfall deficit (FAO, 2015). It is produced in more than 86 countries around the world and on over an area of approximately 38 millions hectares (UA-SAFGRAD, 2016). Its global production was estimated at 2.335.0063 tons. Sorghum is produced in the northern regions of Cameroon for human consumption. It production during 2019 agricultural campaign was estimated at 500.220.50 tons for the rainfed sorghum and 269.926.30 tons for the off-season on respective areas of 346.579.90 hectares and 18.201.101 hectares (MINADER/DESA, 2010). This production is compromised by insects notably Lepidoptera (Djodda *et al.* 2019b) which are phytophagous during their larval stages. This behavior acts as a major constraint on availability of this cereal (Mohamed, 2006). The finds of Djodda *et al*. (2019b) demonstrated that stem-boring Lepidoptera, which are defoliating during the first larval stages, constituted the main constraint to the production of the off-season soghum. The hypothesis of a rainfed season sorghum-off season sorghum cross infestation was then put forward. Since the invasion of Africa by the Fall Armyworm (FAW), *Spodoptera frugiperda* (Lepidoptera: Noctuidae, J.E. Smith) (Goergen *et al*. 2016 ; Cock *et al*., 2017 ; Germain *et al*., 2017) which now coexists in Africa with native species, sorghum producers have faced, in recent years, massive attacks from Defoliating caterpillars during the vegetative stage of the development cycle of the plant. According to Sagar *et al*. (2020), *S. frugiperda* J.E. Smith causes significant damage to cereal fields in Africa and elsewhere in the world. This poses a threat to food security (Goergen *et al*., 2016 ; Day *et al*., 2017 ; Abrahams *et al*., 2017). According to some authors (Day *et al*., 2017 ; Abrahams et al., 2017), yield losses could reach 8.3 to 20.6 million tons on maize in Africa due to the presence of FAW alone. The presence of *S. frugiperda* J.E. Smith in Africa, simultaneously creates competition with native species and a likely increase in damage in the fields. It is therefore imperative to investigate the biological diversity of these defoliating caterpilars and to determine the levels of damage to rainfed sorghum under the natural conditions of infestation in the Far North Region of Cameroon. The main objective of this study is therefore to contribute to the development of ecological control measures of these pest ; since in an integrated control strategy, damage abundance of pest assessment are essential (Bagg *et al*., 2017) for decision-making.

1-Materials and methods

1-1 Sampling and data collection

Sampling took place from June to July 2024 in farmers' fields under natural infestations in the Diamare Division, in the Far North Region of Cameroon. All the fields in this administrative unit were considered as a homogeneous block from the point of view of agricultural practice. This block was then divided into many sub-blocks as there are Sub-Division. Six of the seven Sub-Division were sampled. In each Sub-Division, 5 localities were chosen according to the accessibility criterion. Four fields, randomly selected in each locality, were sampled. Thus, each field is divided into four parts and in each quarter, a quadrat of 10 m^2 is demarcated and the total plants (N), the plants showing signs of attack (n) are counted. The attack rates of each quadrat (Tq), of each field (Tch), of each locality (Tlo) and of each Sub-Division (Tar) are calculated according to the following formulas : Tq = n/N x 100 ; Tch = (Tq1+Tq2+Tq3+Tq4)/4 x 100, Tq1 to Tq4 being the attack rates of quadrats 1 to 4 of each field ; Tlo=(Tch1+Tch2+Tch3+Tch4)/4 x 100, Tch1 to Tch4 being the attack rates of the fields in the locality; Tar=(Tlo1+Tlo2+Tlo3+Tlo4+Tlo5)/5 x 100, Tlo1 to Tlo5 being the attack rates of the localities in the Sub-Division. The caterpillars found on infested plants are collected and identified to species level using reference documents (Miranda *et al*., 2013 ; Gourmel, 2014). Unidentifiable caterpillars are reared until the adult emerges and then identified as previously, using the identification key from Mignon *et al*., (2016).

1-2-Data processing and analysis

The data was entered and processed using the Excel Workbook. An Analysis of Variance (ANOVA), at a threshold of 95%, was carried out and where there is a statistically significant difference, tests of multiple comparisons of means were carried out using the STATGRAPHICS Centurion 16.1 software.

2-Results and discussion

2-1-Results

2-1-1-Biodiversity

Caterpillars are larval stage of Lepidoptera. They are herbivorous. Varying in their voracity depends on their species and on the host plant. Through their feeding on cultivated plants such as rainfed sorghums during the vegetative phase, they lead to a reduction in photosynthetic surfaces and a drop in field densities which can cause loss of yield. The survey in the fields of the Diamare Division showed an environment colonized by a guild made up of 9 species belonging to 6 Genera and 6 Families of insects (table 1).

Table 1 : Biodiversity and relative abundance of defoliating caterpillars

Family	Genera	Species	Relative abundance (%)
Nymphalidae	*Danaus*	*erippus*	0,38
Noctuidae	*Spodoptera*	*exempta*	1,14
		frugiperda	73,00
		littoralis	7,60
Papilionoidae	*Papilio*	*polyxenes*	6,08
		sp	3,80
Notodontidae	*Thaumetopea*	*processionae*	7,22
Tortricidae	*Celypha*	sp	0,38
Nymphalidae	*Anglais*	*urticae*	0,38
Total = 6	Total = 6	Total = 9	100 %

The species *Spodoptera frugiperda* J.E. Smith is still the most abundant in all the localities sampled and in all the Districts (Table 1 and Figure 1). It represented 73.00% of all the caterpillars harvested in the fields. The species *Danus erippus*, *Celipha* sp and *English urticae* are the least represented (0.38%). The genus *Spodoptera*, represented by three species : *S. frugiperda* J.E. Smith, *S. littoralis* and *S. exempta*, represented 81.75% of the caterpillars collected.

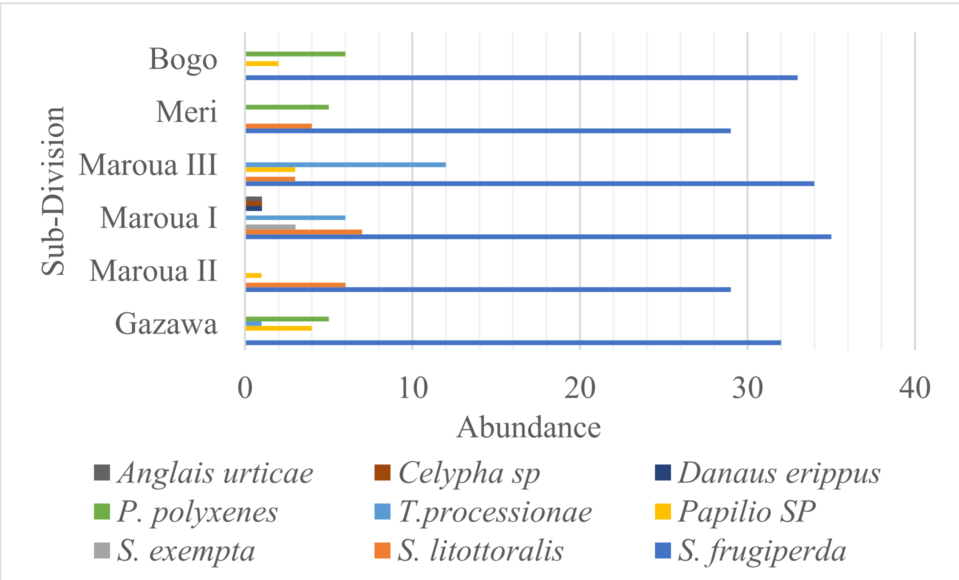

Figure 1 : Abundance of different caterpillar species by District

1-1-2-Incidence

The incidences recorded across the different sub-blocks (sub-divisions) vary from one locality to another. In the sub-block of Méri, where the highest rate was recorded, the incidence varies from 12.90% to 24.19%. The lowest incidence was recorded in the sub-block of Maroua 2 and Maroua 3 ; it was estimated at 12.74% of attack. The incidence in these mentioned sub-blocks varies respectively from 12.74% to 18.38 and from 12.74 to 18.49. In Maroua 1, the estimated incidence varies from 13.22% to 16.85% ; In the two sub-blocks, Bogo and Gazawa, the estimated incidence varies respectively from 13.28% to 18.80% and from 14.48% to 16.41%.

Table 2 : Analysis of Variance (ANOVA) table in sub-blocks at 95% threshold

Souce / Sub-Division	Sum of squares	Ddl	Means square	F	Probability
Meri					
Inter-groups	278,782	4	69,6955	8,74	0,0008
Intra-groups	119,678	15	7,97853		
Total (Corr.)	398,46	19			
Maroua 1					
Inter-groups	31,1121	4	7,77802	0,91	0,482
Intra-groups	127,899	15	8,52659		
Total (Corr.)	159,011	19			
Maroua 2					
Inter-groups	108,791	4	27,1977	10,11	0,0004
Intra-groups	40,3404	15	2,68936		
Total (Corr.)	149,131	19			
Maroua 3					
Inter-groups	93,503	4	23,3757	2,41	0,0947
Intra-groups	145,244	15	9,68291		
Total (Corr.)	238,747	19			
Bogo					
Inter-groups	83,1303	4	20,7826	2	0,1467
Intra-groups	156,09	15	10,406		
Total (Corr.)	239,22	19			
Gazawa					
Inter-groups	13,9923	4	3,49807	0,25	0,9053
Intra-groups	210,062	15	14,0041		
Total (Corr.)	224,054	19			

Comparisons of these average rates of infestation in sub-blocks, using ANOVA test at a significance level of 95%, are reported in Table 2. It emerges that, there are statistically significant differences in damage levels only between the localities of Meri and between the localities of Maroua 2, the respective probabilities (0.0008 and 0.0004) being all less than 0.05. Pairwise comparisons between the localities of Meri are shown in Tables 3a and 3b below. This results show three homogeneous groups with statistically significant différences infestation rates between the localities of the different groups. A statistically significant difference is detected between the average rates of infestation in Mabang and all other localities of Méri, between Godola and the localities of Djébé and Kalio.

In Maroua 2, multiple comparisons of average rates of infestation, using the Fisher Test (LSD Method), indicated in Tables 4a and 4b, make it possible to constitute three groups with homogeneous infestation rates in each group and a statistically significant difference between the localities of two different groups. At a confidence level of 95%, the infestation rate in Mouagazan is statistically different from that of Sékandé, Missiguiléo and Wélin. Similarly, the infestation rate is different between the Missiguiléo-Gayak couple and the Sékandé-Gayak couple. Comparison of average rates of infestation at the Divisional level did not shown any statistically significant difference, the probabilities being all above 5%.

Table 3a : Homogeneous groups of localities of Méri after pairwise comparison test with the 95.0% LSD method

Locality	Workforce	Average	Homogeneous Groups		
Godola	4	12,904	X		
Mikiri	4	15,6628	X	X	
Djebe	4	17,634		X	
Kaliao	4	18,3828		X	
Mabang	4	24,1875			X
Lines wiht X, at the same level form an homogeneous group					

Table 3b : Pairwise comparisons between the localities of Meri using 95,0 % LSD method

Contrast	Sig.	Différence	+/- limits
Mabang - Kaliao	*	5,80475	4,25718
Mabang - Djebe	*	6,5535	4,25718
Mabang - Godola	*	11,2835	4,25718
Mabang - Mikiri	*	8,52475	4,25718
Kaliao - Djebe		0,74875	4,25718
Kaliao - Godola	*	5,47875	4,25718
Kaliao - Mikiri		2,72	4,25718
Djebe - Godola	*	4,73	4,25718
Djebe - Mikiri		1,97125	4,25718

Godola - Mikiri		-2,75875	4,25718
Star (*) indicates a significative statistical difference of the couple			

Table 4a : Homogeneous groups of localities of Maroua 2 after pairwise comparison test with the 95.0% LSD method

Locality	Workforce	Average	Homogeneous groups		
Missinguileo	4	12,1327	X		
Sekande	4	12,7335	X		
Welin	4	13,7747	X	X	
Gayak	4	16,2115		X	X
Mouagazan	4	18,3895			X
Lines wiht X, at the same level, form an homogeneous group					

Table 4b : Pairwise comparisons between the localities of Maroua 2 using 95,0 % LSD method

Contrast	Sig.	Difference	+/- limits
Sekande – Missinguileo		0,60075	2,47164
Sekande – Mougazan	*	-5,656	2,47164
Sekande – Gayak	*	-3,478	2,47164
Sekande – Welin		-1,04125	2,47164
Missinguileo – Mouagazan	*	-6,25675	2,47164
Missinguileo – Gayak	*	-4,07875	2,47164
Missinguileo – Welin		-1,642	2,47164
Mouagazan – Gayak		2,178	2,47164
Mouagazan – Welin	*	4,61475	2,47164
Gayak – Welin		2,43675	2,47164
Star (*) indicates a significative statistical difference of the couple			

2-2 Discussion

S. frugiperda J.E. Smith, an invasive species (Kolar and Lodge, 2001), is believed to have reached and invaded Africa not due to human activities but rather the species' ability to reproduce and disperse (FAO, 2018; Capinera, 2020). According to Johnson (1987), when prevailing winds are favorable, the Noctuid can travel 100 kilometers in one night. Niche occupation in Africa has been to the detriment of native species due to widespread interspecific competition among insects (Reitz and Trumble, 2002). Reitz and Trumble demonstrated that in 33% of cases, the invasive alien species displaces the native species and in 55% of cases another previously established alien species. Analysis of our samples from rainfed sorghum fields shows a species (*Spodoptera frugiperda* J.E. Smith) that is very competitive in exploiting the different resources provided by the sorghum plant in the field. The other *Spodoptera* species, *S. exempta* and *S. littorali*s, found in the same sites as *S.*

frugiperda J.E. Smith along with 6 other species, are weakly represented. The exclusion of other species, not found on rainfed sorghum or their decline in the exploitation of peripheral niches is a result of interspecific competition (Duyck, 2005). *S. frugiperda* J.E. Smith, by its behavior, deprives or influences other species in the exploitation of resources provided by rainfed sorghum. *Spodoptera frugiperda* J.E. Smith, more competitive than other native species, is then the cause of the increase in damages observed in the fields.The tropical and subtropical environments newly invaded by this species, by their entomofauna and cultivated vegetation, are different from its original environment. Cultural practices, the varieties present and the entomofauna of natural enemies that would have been a constraint to its successful establishment seem to be less effective. More investigations into the biology and ecology of this species in Africa would help to its better management. In addition, the fact that the caterpillars of *S. frugiperda* J.E. Smith feeds on more than 350 plants from 75 botanical families (FAO, 2021) raise questions about the possible emergence of strains adapted to sorghums in Africa. In plant-insect relationships, the conflict outcome is difficult to be quantify. Several factors are involved. The plant's defense mechanisms influence pest populations and the ways in which insects circumvent this defense are constantly tested. The observed incidence is therefore a result of several factors including the varieties of plants present, the climate and cultural practices. Our investigations in 30 locations spread across 6 districts show variable levels of infestation from one location to another. Kalqutny *et al*. (2021), working on 50 plants from 5 locations in Indonesia, found incidences of *S. frugiperda* J.E. Smith also variable and up to 87% on maize. Boyombe *et al*. (2021) found attack rates in the DRC varying from 64.5% to 75.5% on maize by *S. frurgiperda* J.E. Smith. Pure corn fields were more attacked than corn fields associated with other crops. This highlights the influence of cultural practices on pests. The relatively lower incidences in our localities compared to those found by the authors above could be explained by the fact that Meri, like the other sampled localities in the region, is characterized by difficult access to arable land and mixed farming is almost the rule. The high incidence in Meri can be explained by the fact that cotton production is reduced and the application of often broad-spectrum insecticides is therefore limited compared to other sampled localities. *Spodoptera frugiperda* J.E. Smith, which constitutes more than 70.00% of the defoliating caterpillars encountered, known for its polyphagy (Prasanna *et al*., 2018), is then indirectly controlled. Furthermore, the infestation rates observed in sorghum fields are always lower than those noted on maize (Boyombe *et al*., 2021; kalqutny et al., 2021 and Mbaïdira *et al*., 2021), which confirms the higher susceptibility of maize to *S.frigiperda* J.E. Smith. Mbaïdira *et al*. (2021) had highlighted in Chad the existence of maize varieties less susceptible to attacks by this major pest. Djodda *et al.* (2019 b) had also demonstrated the existence of varieties of sorghum resistant to stem borers among those produced in the off-season and rainfed sorghums are no exception to defoliating caterpillars such as *Spodoptera frugiperda* J.E. Smith. In the Far North Region of Cameroon, several varieties of rainfed sorghum are sometimes grown on the same plot. Varietal resistance in sorghum, combined with farmers' mixed farming practices, has reportedly led to lower incidences in sorghum fields.

Conclusion

This work highlights a guild of defoliating caterpillars dominated by an invasive species, *Spodoptera frugiperda* J.E. Smith, which is still abundant in all sampled locations, with such varied incidences. This evidence requires in-depth research on the biology and ecology, even the molecular aspects, of this major pest. Furthermore, the incidence levels on rainfed sorghum, which are always lower than those found on maize, provide an avenue for reflection for integrated management of this pest, including varietal resistance in rainfed sorghum in the far north of Cameroon.

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